UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 21, 2021

MEMORANDUM TO: Matthew W. Sunseri, Chairman
Advisory Committee on Reactor Safeguards

Taylor, Robert signing on behalf of Veil, Andrea on 12/21/21

FROM: Andrea D. Veil, Director
Office of Nuclear Reactor Regulation

SUBJECT: RESPONSE TO ADVISORY COMMITTEE ON REACTOR SAFEGUARDS LETTER REGARDING THE REVIEW OF THE DRAFT NUREG/CR-XXXX, "FUEL QUALIFICATION FOR MOLTEN SALT REACTORS"

The purpose of this memorandum is to provide the U.S. Nuclear Regulatory Commission (NRC) staff's response to the Advisory Committee on Reactor Safeguards (ACRS) letter dated November 22, 2021, (Agencywide Document Access and Management System (ADAMS) Accession No. ML21313A361) regarding the review of the draft NUREG/CR-XXXX, "Fuel Qualification for Molten Salt Reactors" (ADAMS Accession No. ML21245A493).

During the 690th meeting of the ACRS, held November 2, 2021, through November 5, 2021; ACRS reviewed the draft NUREG/CR-XXXX, "Fuel Qualification for Molten Salt Reactors," which provides guidance to both the regulator and applicants regarding fuel qualification for molten salt reactor designs. In addition, the ACRS Subcommittee for Metallurgy and Reactor Fuel reviewed this matter, including the draft NUREG/CR itself on October 5, 2021. In a letter dated November 22, 2021, the ACRS provided conclusions and recommendations on NUREG/CR-XXX, "Fuel Qualification for Molten Salt Reactors." The NRC staff reviewed the conclusions and recommendations, and the NRC staff's responses are described below.

The NRC staff also presented this draft NUREG/CR during the November 10, 2021, public Advanced Reactor Stakeholders meeting. The NRC staff will complete the proposed changes below in response to the ACRS recommendations along with any changes resulting from discussions during the public meeting.

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ACRS Conclusion and Recommendation:

The NUREG/CR draft report should be issued once comments in this letter are addressed. Our comments are that the following are needed:

Comment 1:

Discussion regarding the alignment between molten salt safety functions and draft language in 10 CFR Part 53.

The NRC Staff's Response 1:

The NRC staff appreciates this comment and will add a discussion regarding the applicability of the guidance from this draft NUREG/CR to various licensing approaches. By focusing on Fundamental Safety Functions (FSFs), it is intended for this guidance to be universal and to apply to applicants regardless of whether they pursue a Part 50, Part 52, or Part 53 license. Although Part 53 is still under development, the generic nature of FSFs should allow the guidance to be equally useful even if an applicant desires a Part 53 license.

Comment 2:

Additional discussion on beyond design basis fuel salt behavior.

The NRC Staff's Response 2:

The NRC staff agrees with this comment and will add a discussion regarding fuel qualification and its relation to beyond design basis event (BDBE) analyses. The new discussion will describe BDBEs for Molten Salt Reactor (MSR) designs and the roles in which fuel qualification have an impact. It will describe the similarities between Design Basis Event (DBE) and BDBE analyses for MSR designs and will ensure that the fuel behavior is adequately understood to allow DBE and BDBE analyses to accurately predict fuel behavior.

Comment 3:

More discussion on volatilization behavior from a chemical standpoint (e.g., the degree of ideality or non-ideality in the salt.).

The NRC Staff's Response 3:

The NRC staff appreciates this comment and agrees that the ability of the salt to retain fission products is an important attribute for fuel salt qualification. The NRC staff will add a discussion regarding fission product release from fuel salt and will highlight the need to understand fission product retention behavior in the salt for all expected operational states.

Comment 4:

Discussion on salt surface tension to needed list of material properties to model melt-spreading in the event of a spill.

The NRC Staff's Response 4:

The NRC staff appreciates this comment and will add a discussion to address salt surface tension effects in the draft NUREG/CR. The NRC staff agrees that surface tension can potentially impact spill spreading characteristics depending on reactor design, and notes that a vendor can minimize its impacts through careful design. This additional discussion will help highlight potential design considerations to assist in licensing reviews.

Comment 5:

> *Discussion on the impact of thermal hydraulic phenomena associated with liquid fuel on reactivity control.*

The NRC Staff's Response 5:

The NRC staff appreciates this comment and will add a discussion to address potential thermal hydraulic phenomena related to reactivity control for MSRs and the role of fuel qualification to analyze the phenomena. It is noted that the physics of thermal hydraulic phenomena in MSRs is outside the scope of fuel qualification and would instead be addressed by thermal hydraulic design of the reactor; however, it is important for the fuel qualification to address the potential accident conditions that a specific MSR design could experience, and therefore, the fuel qualification should encompass these conditions. The revised draft NUREG/CR will address these fuel qualification concerns related to thermal hydraulic phenomena of the liquid fuel salt.

Comment 6:

> *Discussion on reduction in delayed neutron fraction in molten fuel systems and impact of uncertainty on reactivity control.*

The NRC Staff's Response 6:

The NRC staff appreciates this comment and will add a discussion regarding delayed neutron fraction in molten salt fuel systems. The report will highlight that the fuel behavior (including uncertainties) should be sufficiently understood as part of fuel qualification to allow accurate modeling of core behavior; however, the NRC staff expects that the impact of delayed neutron fraction regarding reactivity control, would be covered by the core design analysis and review.

Comment 7:

> *Discussion of the need for spills to result in subcritical geometries.*

The NRC Staff's Response 7:

The NRC staff appreciates this comment and will add a discussion regarding the role of fuel qualification in supporting criticality analyses. The need for fuel to be qualified and understood to support the criticality analyses for expected or potential geometries is part of fuel qualification and will be included. However, the NRC staff notes that the specific need for spills to result in subcritical geometries is a reactor design topic and would be addressed outside of this draft NUREG/CR.

Comment 8:

Additional discussion on rationale for the salt not having to be deeply subcritical upon shutdown.

The NRC Staff's Response 8:

The NRC staff agrees with this comment and will add a discussion regarding the need to sufficiently understand fuel salt behavior for all operational and accident states. This includes an understanding of fuel salt reactivity behavior to allow accurate reactivity calculations during shutdown. The discussion in the draft NUREG/CR regarding the degree of subcriticality needed during shutdown for certain MSR designs will be clarified.

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